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The Dispersal of Young Stars and the Greater Sco-Cen Association

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Abstract. We review topics related to the dispersal of young stars from their birth-sites, and focus in particular on the entourage of young stars related to the ongoing star-formation event in the Sco-Cen OB association. We conduct a follow-up kinematic study to that presented in Mamajek, Lawson, & Feigelson (2000; ApJ 544, 356) amongst nearby, isolated, young stars. In addition to the η Cha and TW Hya groups, we find several more intriguing Sco-Cen outlier candidates: most notably β Pic, PZ Tel, HD 199143, and HD 100546. We discuss the connection between Sco-Cen and the southern "150 pc Conspiracy" molecular clouds, and in particular, Corona Australis. The kinematic evidence suggests that many of the nearby, isolated $\sim$10 Myr-old stars were born near Sco-Cen during the UCL and LCC starbursts 10–15 Myr ago. We hypothesize that these stars inherited 5–10 km s^{-1} velocities moving away from Sco-Cen, either through molecular cloud turbulence, or through formation in molecular clouds associated with the expanding Sco-Cen superbubbles (e.g. Loop I).

A question arose several times at the YStars conference: "Why are nearly all of the nearby, very young stars located in the southern, rather than northern, sky?" The "Gould Belt" is a general answer, however a more specific answer may involve the nearest, large component of the belt: Sco-Cen. We suggest that the Sco-Cen Association (Sco OB2) is largely responsible for this asymmetry through two mechanisms: the dispersal of stars that formed with the main Sco-Cen OB subgroups in the same giant molecular cloud (GMC) complex; and the concentration of gas and subsequent star-formation initiated by the Sco-Cen superbubbles.

We present our heuristic argument in several steps. First, we provide an historical perspective (§1) and explore mechanisms of the dispersal of pre-main sequence (pre-MS) stars from their natal clouds (§2). In §3, we discuss observations (kinematics, ISM, etc.) linking young stars and groups to the Sco-Cen OB association. Finally, we discuss the possible relationship between the Sco-Cen superbubble and regions of current star formation (§4). Many of these thoughts are built on foundations laid in our earlier studies (Feigelson 1996; Mamajek, Lawson, & Feigelson 2000, MLF00).

1. The missing population of older pre-main sequence stars

Stars are formed in molecular clouds which contain most of the mass but occupy only a tiny portion of the volume of the Galactic disk. Their dispersal into the general star field was historically attributed to relatively slow processes: the evaporation of open clusters, and gravitational scattering processes that produce the observed correlation between stellar age and Galactic scale height. Early studies of the kinematics of pre-MS stars reported radial velocities within $1\,\mathrm{km\,s^{-1}}$ of their natal clouds, with a few exceptions like FK Ser (Herbig 1973), so there was little evidence for early dispersal.

But there was a puzzle: for many years, stars in the intermediate stage of stellar evolution between the classical T Tauri stars and the Zero-Age Main Sequence could not be found near molecular clouds (Herbig 1978). They obviously must exist in considerable numbers, just as there must be an order of magnitude more children of ages $1 - 10$ yr old than there are infants with ages < 1 yr in any steady-state human population.

A significant portion of this missing population of intermediate-aged pre-MS stars was finally found among the $\sim 10^5$ sources of the *ROSAT* All-Sky Survey (RASS). Unlike infrared excesses or prominent optical emission lines, X-ray emission is elevated $10^1 - 10^4$ above main sequence levels for the entire duration of the pre-MS phases, and thus provides an excellent criterion to distinguish older pre-MS stars from the general Galactic star population (Feigelson & Montmerle 1999). In an important series of papers, *ROSAT* scientists spectroscopically identified dozens of lithium- rich, magnetically active weak-lined T Tauri stars (Neuhäuser 1997, and references therein). Unlike traditional T Tauri samples that were spatially concentrated around molecular clouds, the young RASS stars typically lie several to tens of parsecs from any active star forming region. For our discussions, recall that 1 $\mathrm{km\,s^{-1}}$ translates into $1.0\,\mathrm{pc\,Myr^{-1}}$.

Nearly 10^4 RASS sources are associated with stars in the Tycho astrometric catalog ($m_V < 11$), and many are concentrated along the Gould Belt of molecular clouds and OB associations (Guillout et al. 1998). When X-ray flux limits and the full extent of the Gould Belt are taken into account, the RASS sources represent a population of tens of thousands of young stars. Clearly many of the missing older pre-MS stars have now been located.

2. Theoretical origins of dispersed young stars

This discovery of so many widely dispersed X-ray-emitting pre-MS stars requires that much of the stellar dispersal from active star-forming regions occurs on timescales of $10^6 - 10^7$ yr. Several ideas have emerged to explain this phenomenon.

1. Stars may undergo gravitational scattering during their protostellar or T Tauri phases resulting in the ejection of some stars at high velocities (Sterzik & Durisen 1995; Reipurth 2000; Sterzik, this volume). This process preferentially occurs in triple systems where a hard binary ejects the third member. This process has specific predictions. The run-away pre-MS stars should: a) be single and not in multiple systems; b) have a mass

function biased towards low masses, with many brown dwarfs; and c) have space motions that point radially from known modern star-forming regions. There is little evidence that the dispersed RASS young stars have these properties. As the dynamical arguments are convincing, it seems likely that dynamically ejected stars will be found with the deeper astrometric surveys such as *FAME* (Greene, this volume) and *GAIA*.

2. Rather than ejecting stars from molecular clouds, pre-MS stars may appear isolated because their molecular clouds disappear shortly after star formation occurs (e.g. Palla & Galli 1997). There is evidence that star formation occurs over a short timescale within a given molecular cloud (Elmegreen 2001) and, if the cloud is quickly dispersed by stellar radiation and outflows, the resulting pre-MS stars would appear dispersed among older Galactic populations. This model predicts frequent formation and dissolution of molecular clouds and near-coevality of the stellar populations produced ($<$*few* Myr).

3. Pre-MS stars may be widely dispersed because they inherit the motions of their natal molecular gas, which exhibits supersonic motions on large scales in GMCs (Feigelson 1996). Groups of stars from different parts of a GMC will inherit motions from cloud turbulence and will be dispersed over tens of parsecs during their pre-MS evolution. This model is supported by a wealth of observational evidence for velocity dispersions of order $5-10$ km s^{-1} on scales of $20-100$ pc in molecular cloud complexes. For example, CO maps of the Ophiuchus clouds, with 10^4 $M_{gas,\odot}$ and 10^2 $M_{stars,\odot}$ of young stars, and Orion clouds, with 10^5 $M_{gas,\odot}$ and 10^3 $M_{stars,\odot}$ show radial velocity gradients of $6-11$ km s^{-1} (e.g. de Geus et al. 1990; Tatematsu et al. 1993; Miesch et al. 1999). In the larger clouds, these high-velocity motions are shared by the massive cores where rich star clusters form, as well as smaller cores and cloudlets. Truly giant cloud complexes, like W51 with 10^6 $M_{gas,\odot}$ and 10^4 $M_{stars,\odot}$, show velocity dispersions around 20 km s^{-1} on scales of 100 pc (Carpenter & Sanders 1998). Such high velocities are ubiquitous in molecular cloud complexes, and are summarized by the relationship $\Delta v \simeq 5$ km s^{-1} (r/50 pc)$^{1/2}$ (Larson 1981; Efremov & Elmegreen 1998). This relation and other fractal properties of molecular clouds are commonly interpreted as manifestations of supersonic MHD turbulence (Vázquez-Semadeni et al. 2000).

Given the evidence for supersonic gas motions, it is difficult to imagine that many pre-MS stars born in a GMC complex would *not* be endowed with 5–10 km s^{-1} velocities upon birth (Feigelson 1996). Members of a cluster produced by a massive molecular core with a small velocity dispersion will appear as an easily-found rich star association. But it will be surrounded by an inhomogeneous halo of sparser star clusters produced in smaller molecular cores. After 10 Myr, the dispersed star complex may be spread over $\sim$100 pc with space motions convergent to a 20–50 pc region representing the parental molecular cloud.

3. Are the dispersed young, nearby stars Sco-Cen outliers?

The Sco-Cen OB Association provides a unique laboratory for evaluating the dispersal of young stars. Sco-Cen (Sco OB2) is the nearest region of recent and on-going high-mass star-formation to the Sun (see review by Blauuw 1991), and its projected boundaries encompass ∼5% of the sky (de Zeeuw et al 1999; dZ99). Sco-Cen consists of 3 OB subgroups: Upper Sco (US; 5–6 Myr; 145 pc), Upper Centaurus Lupus (UCL; 14–15 Myr; 142 pc), Lower Centaurus Crux (LCC; 11–12 Myr; 118 pc; de Geus et al. 1989; dG89). de Geus (1992; dG92) summarized the studies of the early-type stellar populations of Sco-Cen as well as their effects on the local interstellar medium (winds & supernovae; later discussed in §4).

In our recent study (MLF00), we present an argument connecting the origins of three dispersed pre-MS stellar groups to Sco-Cen: the compact η Cha cluster (d = 97 pc, age ≃ 8 Myr; Mamajek, Lawson, & Feigelson, 1999, Lawson, this volume); the extended TW Hydra Association (TWA, $d \simeq 55$ pc, age ≃ 10 Myr, see Webb, this volume); and a small group of stars near ϵ Cha ($d \simeq 110$ pc, age ≈ 5–15 Myr; MLF00). Their space motions are moving nearly radially away from the two oldest Sco-Cen OB subgroups and their ages are consistent with the times of minimum separation from the subgroups.

3.1. A search for new candidate outliers of Sco-Cen

We suggest that η Cha, ϵ Cha and the TWA are only part of a dispersed population of Sco-Cen outliers formed in/near the Sco-Cen GMC 5–15 Myr ago. Some of these outliers should lie, by chance, quite near the Sun and thus constitute excellent targets for the study of pre-MS stellar and disk evolution. To pursue this idea, we compiled from the literature a heterogenous list of other young dispersed Li-rich dwarfs, Herbig Ae/Be stars, and disked early-type stars in the solar neighborhood. Our primary astrometric data sources are the *Hipparcos* (ESA 1997) and Tycho-2 catalogs (Hog et al. 2000), and we take radial velocities (v_R) from the compilations of Barbier-Brossat et al. (2000) or Maloroda et al. (2001), unless otherwise noted. We calculate and compare the motions of these stars to Sco-Cen as described in MLF00, assuming constant linear motion over the past ∼15 Myr (i.e. over the known star-formation history of Sco-Cen). We considered an outlier candidate to be a star which was within ∼50 pc of a Sco-Cen subgroup within the past 15 Myr. We omit the Galactic potential, since this interval is much smaller than the epicyclic (κ) and vertical (ν) periods. We claim this is satisfactory for this initial effort. The dangers in extrapolating stellar motions back in time are nicely summarized by Soderblom et al. (1990), however most of the objections pertain to longer intervals and older groups (>100 Myr). Here, we report a few interesting cases:

• **HD 100546** (B9Ve; ℓ, b = 296.4^o, –8.3^o; $d \simeq 103$ pc) is an isolated Be star apparently associated with the dark cloud DC 296.2–7.9 with a lower-limit age of >10 Myr (van den Ancker et al. 1998). dZ99 list it as an LCC member by virtue of its Hipparcos astrometry, and it lies on the southern periphery of the subgroup. HD 100546 is very close (0.6°) to a co-distant, co-moving star: **HD 101088** (F5IV; $d \simeq 101$ pc). Vieira et al. (1999) claim HD 101088 is an unrelated foreground star, however dZ99 list it as another LCC member. We calculate a space motion of U,V,W = (–10.5, –19.7, –7.7) ± (1.1, 1.0, 0.5) km s^{-1} for HD

100546, which is only 2 km s^{-1} from the motion of LCC. HD 101088 should have an identical v_R as HD 100546 to confirm its status as a pre-MS LCC member.

• **51 Oph** (A0Ve; ℓ, b = 2.5°, +5.3°; $d \simeq 131$ pc) is one of the most unusual disked Herbig Ae stars yet identified, and its status as pre-MS vs. post-MS is still unclear (van den Ancker et al. 2000a). With a U,V,W space motion of (–9.8, –12.3, –12.3) ± (2.4, 1.3, 1.4) km s^{-1}, 51 Oph was within ∼20 pc of US some 4 Myr ago. This is similar to the age of the US subgroup (dG89). It is moving away from US at 9 km s^{-1}, and we consider it an US outlier candidate.

• **HD 199143** (F8V; ℓ, b = 30.4°, –35.0°; $d \simeq 48$ pc) van den Ancker et al. (2000b, this volume) describes this F8V star as an isolated ∼10 Myr-old star with a T Tauri-type companion, **HD 358623**. They report $v_R = -9 \pm 16$ km s^{-1} for HD 199143, giving it a space motion of (–11.0, –15.8, –9.2) ± (11.3, 6.7, 9.2) km s^{-1}. We investigate the motions of HD 199143 for v_R values within the error bars, and find the star was within 40 pc of the UCL subgroup ∼13 Myr ago for $v_R \simeq -9 \pm 2$ km s^{-1}. With that v_R, the HD 199143 system is an UCL outlier candidate, moving away from UCL at ∼10 km s^{-1}.

• **V824 Ara** (K1Vp; ℓ, b = 324.9°, –16.3°; $d \simeq 31$ pc) Pasquini et al. (1991) made a strong case for this star being pre-MS instead of post-MS, and Strassmeier & Rice (2000) quote an age of 18 Myr. With a space motion of (–7.9, –18.9, –10.3) ± (1.0, 0.9, 0.5) km s^{-1}, we find that V824 Ara was within ∼25 pc of UCL ∼12 Myr ago, and is moving away from UCL at 7 km s^{-1}.

• **V343 Nor** (K0V; ℓ, b = 323.8°, –1.8°; $d \simeq 40$ pc). This is a nearby young, magnetically active star discussed by Anders et al. (1991) as a "Local Association" member. Its Li λ6707 EW of 302 mÅ suggests an age younger than IC 2602 (<30–50 Myr). We calculate a space motion of (−10.8, −16.8, −10.2) ± (1.0, 0.9, 0.5) km s^{-1}, which places V343 Nor about ∼40 pc from the UCL subgroup ∼9 Myr ago. V343 Nor is moving away from UCL at about 10 km s^{-1}.

• **PZ Tel** (K0Vp; ℓ, b = 346.2°, –20.8°; $d \simeq 50$ pc). Favata et al. (1998) estimate the age of this well-studied active dwarf to be ∼20 Myr old. Using the space motion from Barnes et al. (2000), we find that PZ Tel was within ∼40 pc of UCL ∼13 Myr ago. PZ Tel is moving away from UCL at 8 km s^{-1}.

• β **Pic** (A5V; ℓ, b = 258.4°, –30.6°; $d \simeq 19$ pc). Barrado & Navascues et al. (1999; B&N99) estimated an age of 20 ± 10 Myr for this prototype disked A star, and we use their U,V,W vector in our analysis. The motion of β Pic is ∼7 km s^{-1} directed away from UCL, and it lay within ∼50 pc of UCL about ∼13 Myr ago. B&N99 find that the two active M dwarfs **GJ 799** and **GJ 803** are comoving with β Pic, and that they are 2 of the 3 most active (youngest) nearby M dwarfs out of a sample of 160. Using the B&N99 space motions, we find that GJ 799 was ∼70 pc from UCL ∼11 Myr ago, and GJ 803 was ∼60 pc from UCL ∼12 Myr ago. The kinematic results and age agreement are very suggestive of a collective Sco-Cen origin, but not overwhelmingly convincing. Much of the separation between these stars and UCL ∼12 Myr ago was in the Z direction, so a future investigation including the Galactic potential will better address the plausibility of the β Pic group (and many of the other candidates mentioned) as being related to the Sco-Cen star-formation event. If the trio are true Sco-Cen outliers, they should have ages of <13 Myr; which is at the low end of recent age estimates (Barrado & Navascues, this volume). A lithium depletion study of the M dwarfs could further address the issue of their ages.

A few other stars appear to be moving away from Sco-Cen very quickly (~15 km s^{-1} for LQ Hya, ~25 km s^{-1} for GJ 182 and EQ Vir) but their lithium abundances suggest they are older than the Sco-Cen subgroups; hence they are clearly unrelated. Other young, active stars (e.g. AB Dor, HD 105, V383 Cen, etc.) have motions and ages completely inconsistent with a Sco-Cen origin. Many could be older Gould Belt stars (~50 Myr), or even young MS disk stars. Here we mention some stars that appear to *not* be kinematically tied to Sco-Cen:

• **FK Ser** (K5Vp; ℓ, b = 20.3°, +2.2°; d ~ 100 pc) is a binary isolated T Tauri star discussed by Herbig (1978). The star has a poor *Hipparcos* parallax ($\pi = 9.42 \pm 6.17$ mas), and we adopt the long-baseline Tycho-2 proper motion which is 2–3× better than Hipparcos'. From Herbig (1973) and Zappala (1974), we calculate a mean $v_R = -10 \pm 3$ km s^{-1}. Calculating space motions within the 1-σ errors for the π and v_R in steps of 1 mas and 1 km s^{-1}, we find no pass near Sco-Cen in the past - hence we do not consider an outlier candidate.

• **HD 163296** (A2Ve; ℓ, b = 7.2°, +1.5°; $d \simeq 122$ pc) is an isolated Herbig Ae star recently found to have both a disk and outflow (Grady et al. 2000). van den Acker et al. (1998) found an age of $4^{+6}_{-2.5}$ Myr from isochrone fitting. Spatially the star is within 10° of, and nearly co-distant with the ρ Oph streamers oriented away from US. We calculate a space motion of (–0.9, –22.9, –7.8) km s^{-1}, which has the star moving *towards* the Sco-Cen subgroups. Despite its proximity to Ophiuchus, we can easily rule out common proper motion with Upper Sco (its nearest Sco-Cen subgroup), and radial motion away from any of the subgroup.

• **HD 17925** (K1V; ℓ, b = 192.1°, –58.3°; $d \simeq 10$ pc). This was the original "Sco-Cen outlier" proposed by Cayrel de Strobel & Cayrel (1989). HD 17925 came no closer than ~80 pc of Sco-Cen in the past. For its spectral type, and Li λ6707Å equivalent width of 200 mÅ (Favata et al. 1997), an age of ~100 Myr would be more appropriate – hence it is unrelated to Sco-Cen.

To summarize our study, we find that several of the extremely young, nearby stars appear to be moving away from Sco-Cen, and have ages younger than or similar to that of the Sco-Cen OB subgroups. Many are not surprisingly, unrelated to this star-formation complex. In **Fig. 1** we plot the motions of the Sco-Cen outlier candidates over the past 12 Myr. The motions are with respect to the oldest Sco-Cen subgroup (UCL; heliocentric U,V,W = –3.9, –20.3, –3.4) km s^{-1}. Note that the ages of some of the groups are younger than 12 Myr (i.e. US, CrA), and but most of the times of closest pass are ~12-13 Myr ago.

3.2. The TW Hya Association and Lower Centaurus Crux

The TWA members with *Hipparcos* astrometry in Webb et al. (1999) had U,V,W vectors consistent with an origin near the LCC OB subgroup some ~10 Myr ago (MLF00). The ages of TWA (~10 Myr) and LCC (11-12 Myr) are nearly identical. *All* of the new TWA members reported by Zuckerman et al. (2001) lie within the projected boundaries of the LCC subgroup (dZ99), and have estimated distances (d ≃ 70–100 pc) even closer to LCC than the original TWA stars (**Fig. 2**). The proper motions (μ) are shown in Fig. 2, but it is mostly solar reflex motion. Fig. 2 also illustrates that searching for new TWA members will uncover increasing numbers of T Tauri stars at southern declinations ($\delta <$ –40°), but these will most likely be bona fide LCC members. A specific example is TWA 19 (HIP 57524) with a *Hipparcos* distance of 104^{+18}_{-13} pc, which dZ99 lists

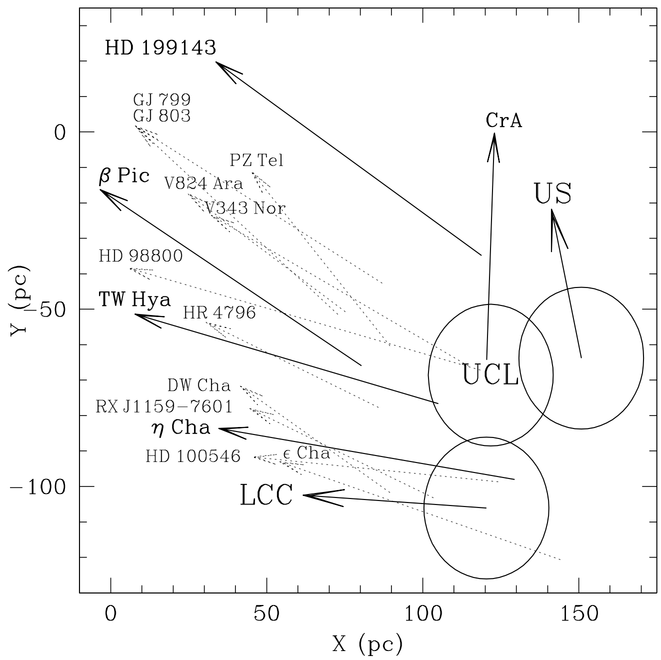

Figure 1. The motions of nearby young stars over the past 12 Myr, with respect to the UCL OB subgroup of Sco-Cen (here, stationary). The current position is at the arrow tip, and the unlabelled end is 12 Myr ago. The 40 pc circles encapsulate the OB subgroups 12 Myr ago.

as a kinematic member of LCC. At a mean distance of 118 pc, the projected width of the LCC subgroup ($\sim$25°) corresponds to a depth of $\sim$50 pc; indeed many of the early-type members are closer than 100 pc (dZ99). Extrapolating from the number of B stars with a typical initial mass function (IMF), dG92 suggests that the total stellar population of LCC is $\sim$1300; most of which will be T Tauri stars. A spectroscopic survey of late-type RASS-Tycho stars has uncovered dozens of LCC T Tauri stars with kinematic distances <100 pc (Mamajek et al., in prep.). The continuity in the distances of TWA and LCC stars, and their coevality lead us to conclude that there is no clear division between TWA ($\sim$$10^{1.5}$ stars) and LCC ($\sim$$10^3$ stars). Despite their nearly coherent motions, it is unclear whether the TWA stars formed individually in isolation (under similar circumstances) or originally from a small cluster analagous to η Cha which has evaporated. Makarov & Fabricius (2001) report an expansion age of 8 Myr for the TWA; however the significance of this measurement is clouded by the inclusion of potential interlopers (i.e. 23/31 of their TWA kinematic members have yet to be confirmed as pre-MS, but were included in the analysis). They, too, conclude that the division between LCC and TWA is tenuous at best.

4. Sco-Cen and the southern "150 pc Conspiracy" molecular clouds

Aside from Taurus clouds, it is well known that most of the nearest molecular cloud complexes lie in the southern hemisphere at a distance around 150 pc. Sim-

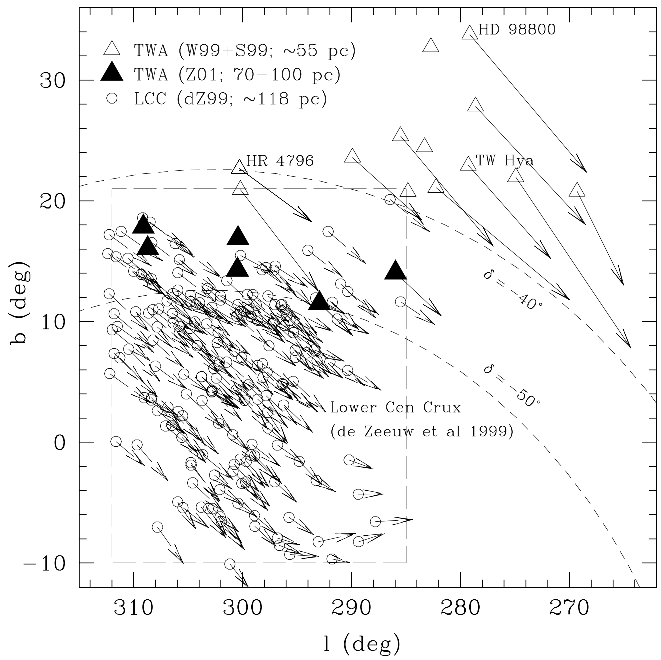

Figure 2. The TW Hya association and the Lower Cen Crux OB subgroup. TWA 1-13 are from Webb et al. (1999) and Sterzik et al. (1999), while TWA 14-19 are from Zuckerman et al. (2001) (see §3.2)

ple application of the initial mass function and stellar evolution indicates that the Sco-Cen subgroups must have had several (∼10) O and early-B stars that have evolved and gone supernovae. The stellar winds and supernova remnants of Sco-Cen O and early-B stars have had a major impact on the surrounding interstellar medium and the progenitor GMC. Using superbubble theory (McCray & Kafatos 1987, Tenorio-Tagle & Bodenheimer 1988), dG92 argue that the energy input from the massive stars in the OB subgroups produced the observed network of superbubbles some ∼100 pc in radius centered on Sco-Cen. The largest of these is Loop I, which is centered on the UCL subgroup.

These superbubbles are seen as a series of arcs of H I and warm dust towards the 4th Galactic quadrant, and encompassing ∼20% of the sky. The high galactic latitude molecular clouds in the southern hemisphere appear to be preferentially placed along the edge of Loop I (Gir et al. 1994). The total H I mass of the superbubbles is $\sim 5 \times 10^5$ $M_\odot$, which is likely composed of gas swept up from the ambient ISM and the Sco-Cen progenitor GMC. The bubbles have expansion velocities of ∼10 $\mathrm{km\,s^{-1}}$ and a total kinetic energy of $\sim 10^{51}$ erg (dG92).

The superbubbles may be responsible for triggering star formation in some or most of the nearby star-forming regions in the southern sky such as Lupus, Ophiuchus, Corona Australis, and Chamaeleon. The Musca and Coalsack clouds may be in the earliest stages of star-formation. All of these lie 100−200 pc from the Sun in the vicinity of the Sco-Cen subgroups. A review of observations and theory relating to the triggering of star-formation in swept-up neutral shells is reviewed by Elmegreen (1998). It has been argued that the ionization front and winds of the massive stars in US is now producing a shock front that is compressing molecular material in the core of the Ophiuchi cloud, and is blowing long cometary tails in the outer part of the cloud (e.g. Loren et al. 1989). The Lupus clouds lies on the edge of the young superbubble around US (dG92), while the CrA molecular cloud is embedded within the thin H I shell associated with the Loop I superbubble (§5). The Coalsack, Musca, and Chamaeleon clouds have also been physically associated with each other through an extended interstellar dust "sheet", which appears to be the thin shell of the Loop I superbubble (Corradi et al. 1997). From the ISM studies mentioned previously, it appears likely that the southern "150 pc" clouds are linked to the on-going Sco-Cen star-formation episode.

5. The Corona Australis Pre-MS cluster: a missing link?

The Corona Australis (CrA) molecular cloud is an active star-forming cloud complex with a compact cluster of protostars (the "Coronet") surrounded by an extended group of T Tauri stars (Neuhäuser et al. 2001, and refs. therein). We calculate the space motion of the CrA group to be (U,V,W) = (–3.7, –15.0, –6.9) km s^{-1} using the mean radial velocity from Walter et al. (1994) (-1.4 ± 0.6 km s^{-1}), the weighted mean μ from several Tycho-2 entries (S CrA, TY CrA, HBC 676, HBC 678, and CrAPMS 4SE) (μ_α, μ_δ) = ($+2.9 \pm 0.8$, -27.4 ± 0.9) mas yr^{-1}, and the distance obtained by Casey et al. (1998) for the eclipsing binary TY Cra (129 ± 11 pc). The stars in the CrA cloud are mostly <3 Myr old. Tracing the motion of the CrA group back, we find that it lay within ∼30 pc of UCL some 14 Myr ago. The CrA complex is moving radially away from UCL at 7 km s^{-1}, similar to the expansion velocity of the Sco-Cen superbubbles (∼10 km s^{-1}; dG92). Cappa de Nicolau & Pöppel (1991) and Harju et al. (1993) found corroborating evidence that the CrA clouds are embedded within the massive H I shell of Loop I. We conclude that the CrA stars have inherited the motion of the CrA molecular cloud, which itself is embedded in the Loop I shell, and the whole complex is moving radially away from the ∼14–15 Myr-old UCL OB subgroup. The superbubble provides a natural mass and momentum source for forming the CrA molecular clouds and its associated stars.

6. Summary

The question "Why are nearly all of the very young, nearby stars located in the southern, rather than northern, sky?" may have a simple answer: "Because of the Sco-Cen Association". The Sco-Cen Association likely has a total population of ∼10^4 stars (dG92), similar to the better-studied Orion complex. As in Orion, several rich associations have formed in Sco-Cen over a ∼15 Myr period, producing the US-UCL-LCC subgroups, as well as many smaller, peripheral molecular clouds and dispersed clusters. These small, unbound stellar groups formed in either the progenitor Sco-Cen GMC, or in short-lived molecular clouds formed by the superbubbles. These groups are partly or fully evaporated today and are now seen as dispersed collections of pre-MS stars that we label as the TW Hya Association, η Cha cluster, β Pic group, etc. Such stellar dispersal over 10s-100 pc over ∼10 Myr is expected if the stars inherited their space motions from clouds which were endowed momentum either from (1) supersonic turbulence in GMCs or (2) formation in molecular clouds associated with expanding superbubbles.

We believe that this scenario provides a convincing explanation for the presense of many (or most) of the isolated, extremely young ($\sim$10 Myr-old) stars in the solar neighborhood. It is supported by the approximate agreement between the kinematic and nuclear ages. Observationally, we see the "process" continue today in the "150 pc" molecular clouds in the vicinity of the Sco-Cen OB subgroup. The key to testing these ideas is higher quality astrometric data: more precise parallaxes, proper motions, and radial velocities for all nearby pre-MS stars. Except for radial velocities which can be obtained from ground-based telescopes, missions like *FAME*, *DIVA* and *GAIA* are critical to this effort.

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